AQUATIC DISEASE SURVEILLANCE
APPLYING EPIDEMIOLOGICAL CONCEPTS TO AQUATIC ANIMAL DISEASES

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Outline

- OIE CC ERAAAD organization
- Sampling considerations
  - Risk-based sampling
- Diagnostic testing considerations

OIE connections

- Member of OIE ad hoc group on Aquatic Animal Disease Surveillance 2006-2012
  - Revised Disease Surveillance chapters in OIE Code and Manual
- Member of OIE ad hoc group on Aquatic Pathogen Differentiation 2010-2012
- With Norway, formed OIE Collaborating Centre in Epidemiology and Risk Assessment of Aquatic Animal Diseases – May 2010

OIE Concerns

- Support international trade / movement of aquatic animals and their products
  - Sanitary security
  - Through most appropriate methods for
    - Surveillance
    - Diagnosis
    - Disease prevention
OIE Perspectives on Surveillance

- 2 primary reasons:
  - Self-declaration of disease freedom, and
  - Pathogen distribution (for control and movement restrictions)

Disease surveillance

- Disease detection
  - A) First cases in previously negative area
  - B) New cases in endemic area
- Involves
  - Disease sampling / testing intensity decisions
  - Disease control actions
  - Movement restrictions

AQUATIC Surveillance issues to consider

- Population is difficult to visualize and quantify
- Large population sizes and value (at group level)
- Limited access to individuals representative of the general population
- Wild-farmed interactions can be intense
- Large number of species and growing environments
- Need strategies to conserve resources and increase probability of detecting cases in early stage of outbreak
Picture this poultry barn:

- Bubble around your chickens so cannot see livestock except if they come close
- Other birds, possibly infected, can enter (and the chickens like to eat the small ones)
- Only humans (usually one at a time and rarely the vet!) with special breathing apparatus can enter
- Feeding chickens is done by throwing pellets in and hope they eat it (maybe use a video camera at the far end)
- Mortalities collect on the floor but other scavengers eat them
- Carcasses decompose very rapidly, so mortality collection is usually mush
- 90% of mortalities are never examined or tested
- “new” pathogens / diseases being discovered every few years
- Expensive to send person in to collect mortalities so only do that once per week unless known problem
- You can sample by standing outside bubble and throwing a net in or feed to bring some closer
- Dealing with 30,000-100,000 chickens per bubble, 10-15 bubbles per farm
- Bubbles are hours drive from a remote location hours away from anywhere else

Surveillance aims to detect when?
But when is detection going to be most reliable?

Testing in apparently healthy populations

- Control & containment measures depend on early detection
- Early detection cannot wait for mortalities to start increasing
- So use healthier individuals to satisfy need for earlier detection
  - First mortalities + samples of swimming fish

Sampling principles

- Random sampling (= probability sampling)
  - Simple random
  - Systematic random
  - Multiple staged, random sampling
    - E.g. area / farm / pond
- Non-random sampling
  - Convenience
  - Risk-based
Access to fish samples

- Very few points in lifecycle when random sample possible
  - Vaccination, handling, transfer into marine pen, etc
  - Harvest
- Catching sick individuals often difficult
- Wild fish – rarely see sick or dead animals
  - unless large proportion of population affected

(systematic) Random Sampling

- Need access to individuals
- Not required to know total population number
  - But MUST continue through entire population being sampled
- Systematic random sampling is most common form of random

Biased sampling

- Convenience samples

Biased sampling

- Risk-based samples
  - Moribund with specific external characteristics known to be more common for disease of interest
Biased sampling

- Risk-based samples
  - Moribund with specific external characteristics known to be more common for disease of interest

Risk-based surveillance

- Goal:
  - Optimize performance of new or existing surveillance systems
  - Intentionally use selective sampling of high-risk sub-populations
    - to increase probability of detecting positive individuals within general population

E.g. Prioritize sample collection from sites with low dissolved oxygen (if environmental insults associated with increased susceptibility to pathogen of interest)
Risk-based Sampling

- Use BIAS to its advantage
  - But it has limitations
- Is bias “direction” known?
  - Assumptions that bias toward detection if sample sick or slow individuals
  - From population perspective:
    - Sample is from “sick population” (i.e. sick segment of population)
- Dangerous IF make an error in the direction of the bias
  - If bias away from infection, decrease probability of inclusion of infected individual

Catchable fish

- Catchable fish (fish that are too slow to escape net)
- 5%
- Catchable fish (fish that will come toward feed / net)
- 1%
- 0.1%
- True Prevalence of Pathogen X

Will increasing sample size fix this bias problem?

NO

- It will make you more confident of your estimate of prevalence in the sub-group

Prevalence vs detection

- Selection bias toward detection is not used to estimate prevalence
  - Unless short duration of clinical disease and most clinical disease leads to mortality
  - Unless other parts of equation are confidently predictable (e.g. probability of inclusion in different sub-populations)
- Detecting ZERO positive in biased (i.e. toward detection) sample is more reliable than ZERO positive in random sample
- Only a few opportunities in production cycle for random sampling
  - Usually handling stresses involved
Disease detection

- Diagnostic tests are imperfect
  - Particularly when attempting to detect asymptomatic individuals
- New cultured species will have new pathogens identified

Diagnostic testing considerations

- Ability of test to correctly detect positive animal / group
- Ability of test to correctly detect negative animal / group
- Test repeatability between labs (or investigators)

Diagnostic tests in aquatic situations

- Disease is frequently assumed to be absent in facilities that lack obvious clinical disease
- Subclinical and carrier states can be common in non-stressed animals
- Diagnostic tests detect poorly for many non-clinical disease states
  - Many new diseases have no tests except general pathology to identify suspicious agents or host responses

Biasing samples can be good

- We routinely bias our samples toward detection
  - By looking for individuals that have characteristics common in the diseased population
    - Smaller individuals (compared to cohorts)
    - Off-feed or altered swimming behaviour
    - Slow swimmers
    - Fish with lesions
- Can identify higher risk farms or clusters of farms to purposively apply same selection bias
Detection is affected by many factors

- Disease level in the individual tested
  - Clinical disease is easier to detect
  - Surveillance of ‘apparently healthy’ individuals is more difficult

**Prevalence in different populations**

Apparent prevalence of different populations (HPR<sub>ani</sub>) of Atlantic salmon in New Brunswick farms (2001).

<table>
<thead>
<tr>
<th>Population</th>
<th>Apparent prevalence (95%CI)</th>
</tr>
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<tbody>
<tr>
<td>A&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.940 (0.887, 0.993)</td>
</tr>
<tr>
<td>B&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.406 (0.279, 0.533)</td>
</tr>
<tr>
<td>C&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.286 (0.204, 0.368)</td>
</tr>
<tr>
<td>D&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.084 (0.009, 0.160)</td>
</tr>
<tr>
<td>E&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.080 (0.004, 0.156)</td>
</tr>
</tbody>
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**Summary**

- Surveillance for Declaration of Disease Freedom:
  - Usually uses sampling strategies that bias toward inclusion in sample
  - Related to illness
- Random samples are difficult in practice
  - Systematic random is possible when have access to individuals
Conclusion

- Optimizing disease control and prevention requires surveillance evidence to support practices.
- Sampling and test performance are two important considerations for surveillance programs.
  - And decisions made from results.